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Title: Source Search Concepts

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Source Search Concepts

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LA-UR-20-XXXXX

Objectives

- List 4 things that affect gamma detection
- List 2 situations where the ISL doesn't work
- List three steps in the '3D-T' search process

Factors Affecting Gamma Detection

Gamma Detection depends on:

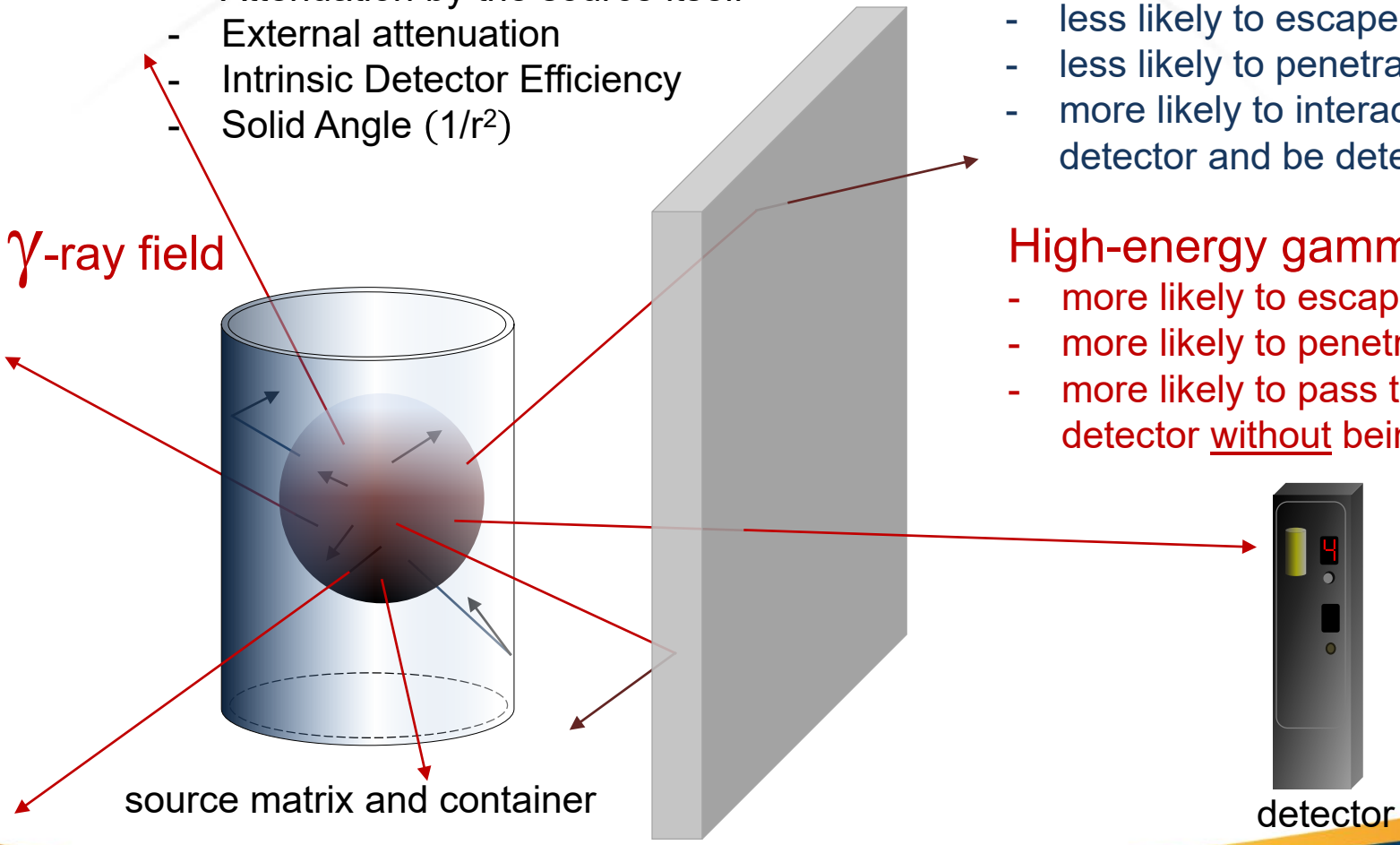
- Attenuation by the source itself
- External attenuation
- Intrinsic Detector Efficiency
- Solid Angle ($1/r^2$)

Low-energy gamma rays are:

- less likely to escape the source
- less likely to penetrate shielding
- more likely to interact with detector and be detected

High-energy gamma rays are:

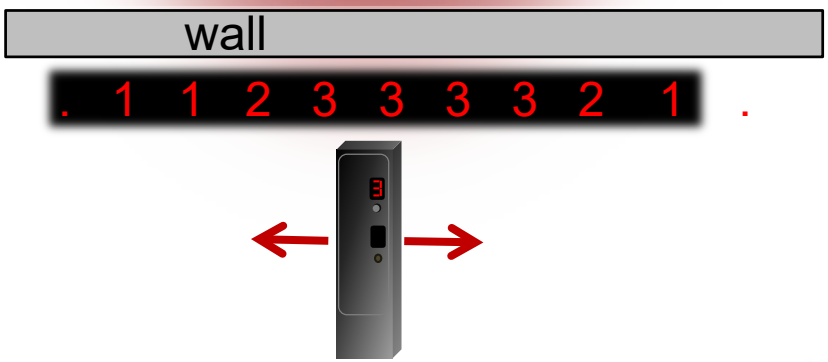
- more likely to escape the source
- more likely to penetrate shielding
- more likely to pass thru the detector without being detected



How $1/r^2$ Affects Radiation Profiles

If the count rate changes quickly with position then the source could be close to the detector.

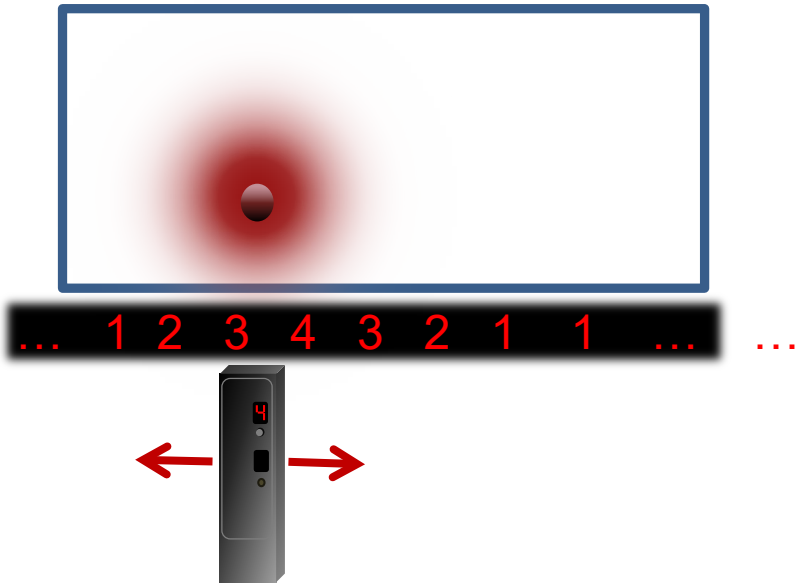
If the count rate changes slowly with position then the source is probably farther from the detector.

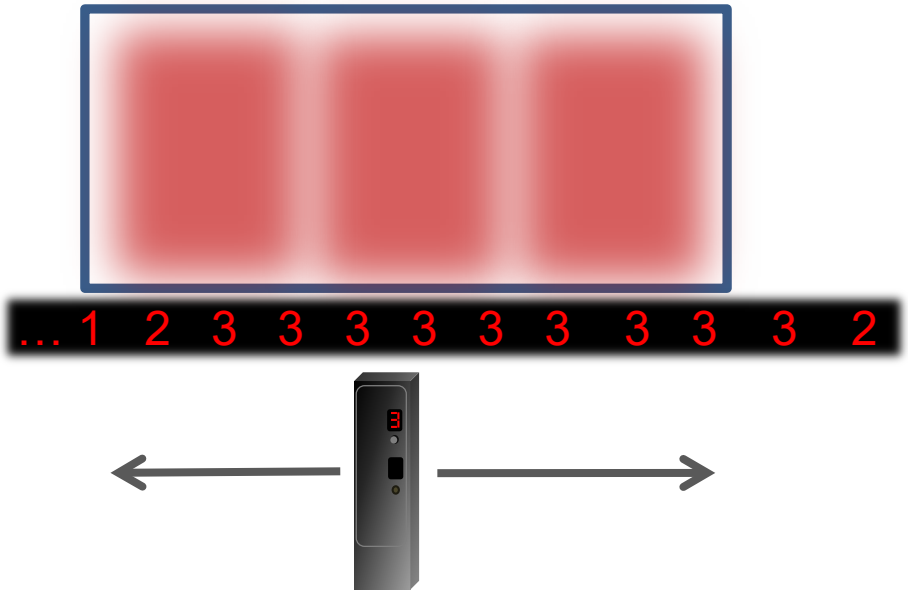


If your readings are roughly the same over several feet, then the source could be several feet behind the wall!

‘Point’ vs Distributed Sources

Here $1/r^2$ does not work so well close to the container





Localized Source:
Possible Threat

Distributed Source:
Likely NORM

Search Patterns

- Random Walk (not recommended)
- Search suspicious objects
- Use the ‘3D-T’ Search Pattern
- Consider the possibility of multiple sources

The “3D-T” Search Pattern

- Search in “T’s” or “90-degree angles”
- Walk a straight line through a search area:

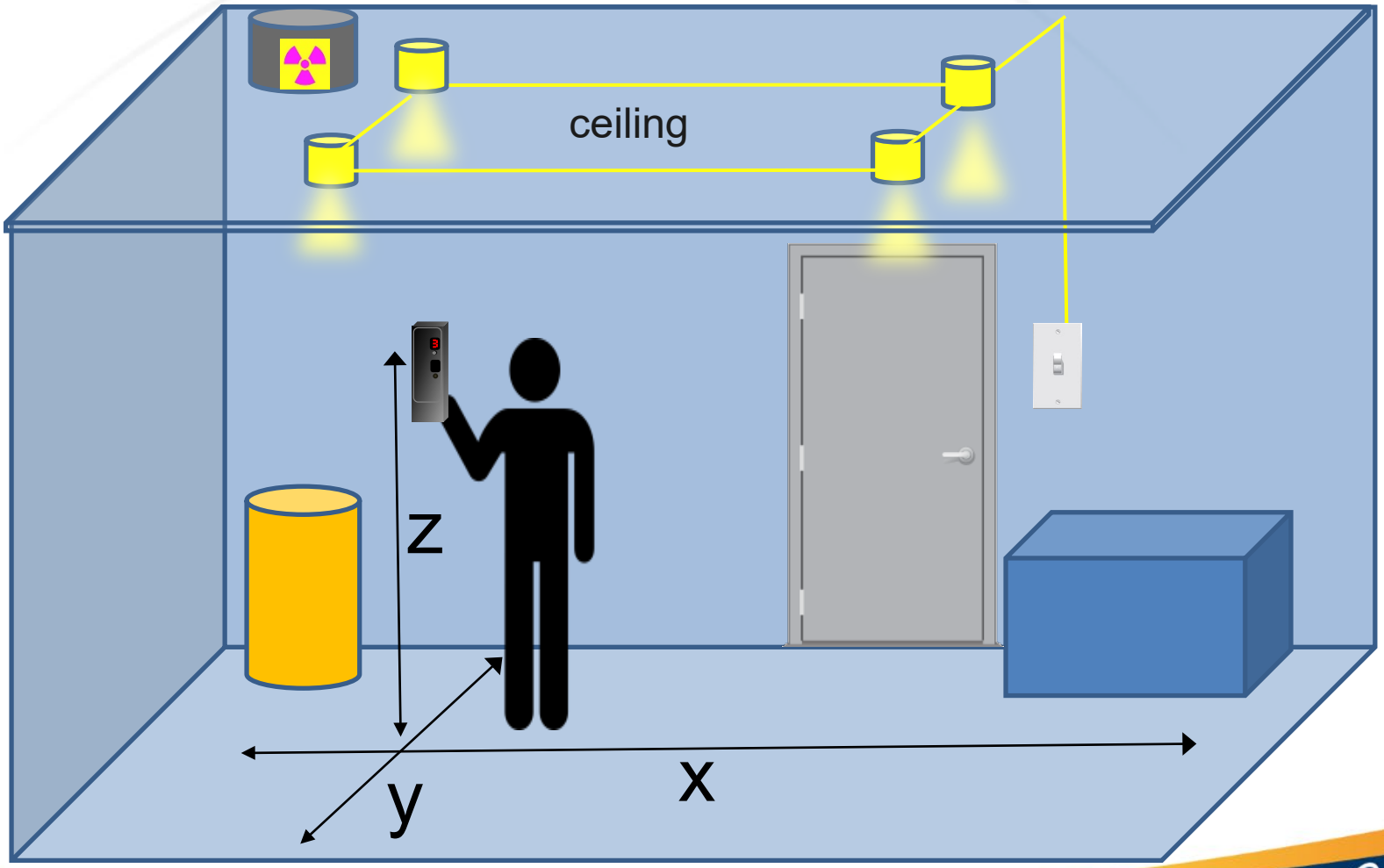
  1) find hotspot in the X direction

  2) From the X hotspot, find the hotspot in the Y direction

  3) From the XY hotspot, find the hotspot in Z

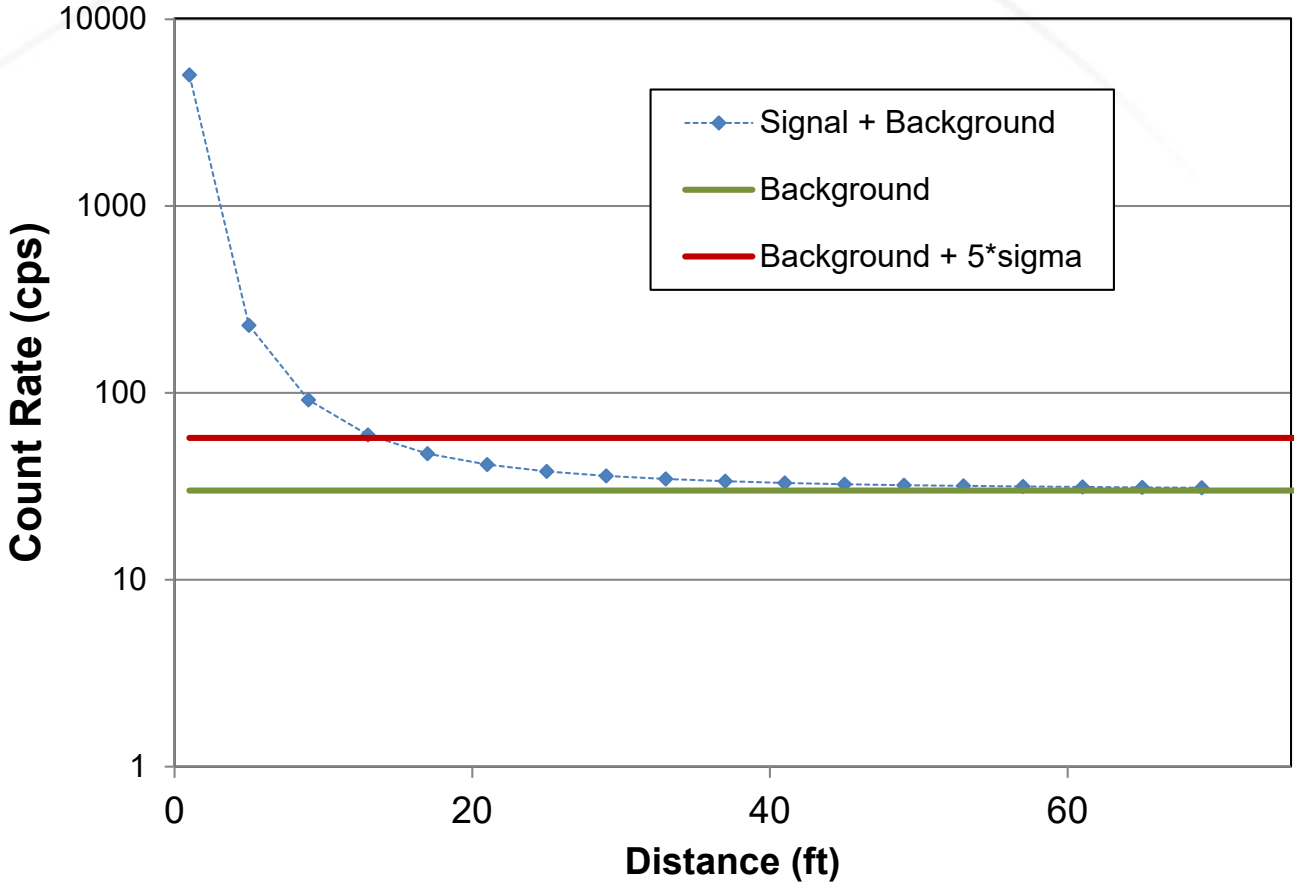
- Consider the possibility of multiple sources
- Search suspicious objects

Use the “3D-T” Search Pattern



Source Intensity & Background

Detection Range and Background

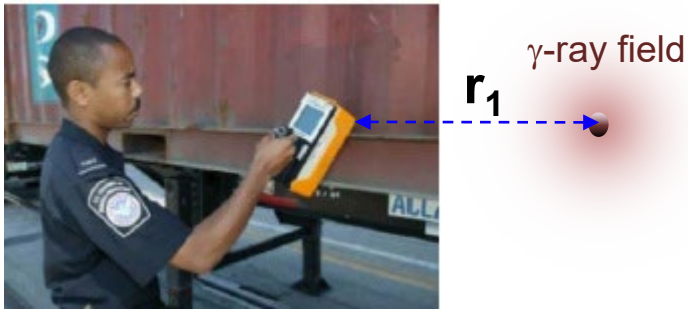


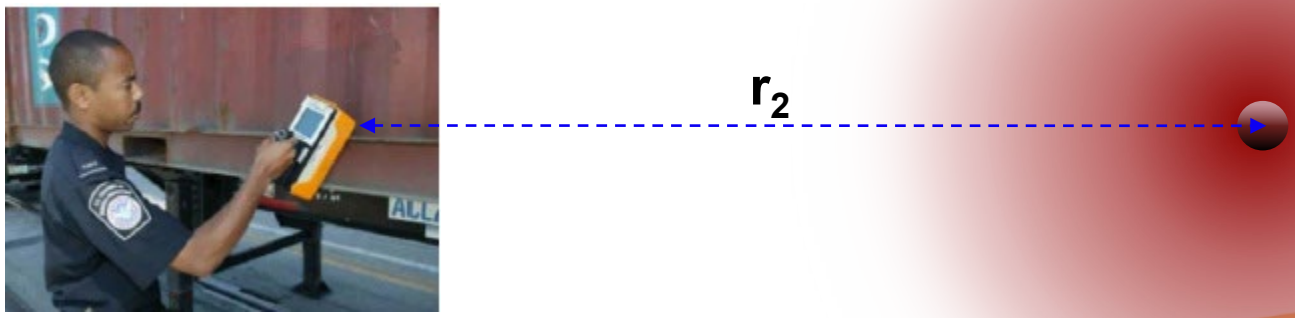
If the signal from the source is barely above background you will have to be very close to it to detect it.

Distance and Source Intensity

The observed count rate in these two cases *could* be the same.

We need to know the source-to-detector distance to estimate the activity or mass of the source.

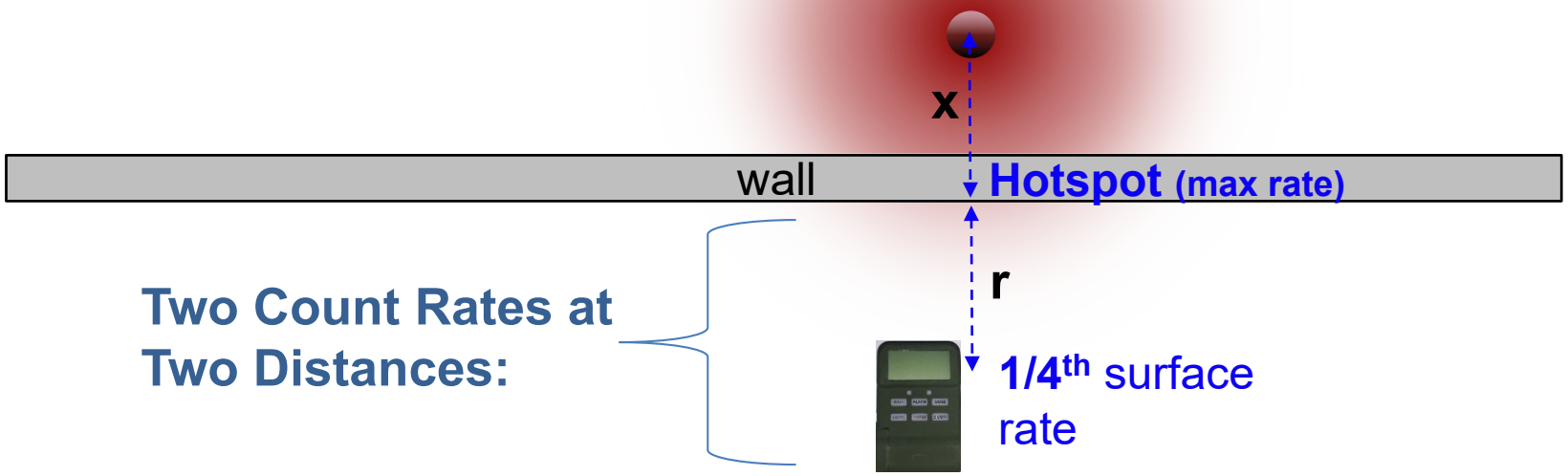




Using $1/r^2$ to Estimate Source Location

Job Aid for the Simple Case:

1) Find the hotspot .
2) Note the count rate on the surface.
3) Then move directly away from the wall until the rate is $1/4^{th}$ what it was at the hot spot.

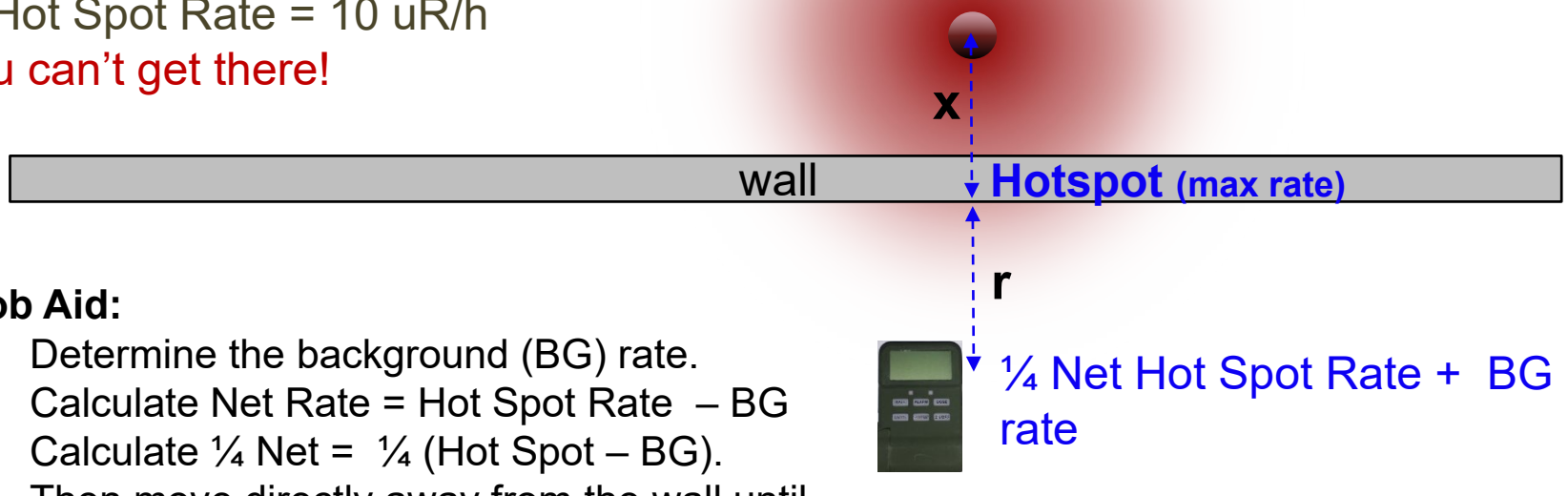


r and x are the same! **So now we know the hotspot-to-source distance.**

Hot Spot Rate Just Above Background

If the count rate is barely above background you must subtract the average background.

Example:
BG = 15 uR/h
Hot Spot Rate = 40 uR/h
¼ Hot Spot Rate = 10 uR/h
You can't get there!

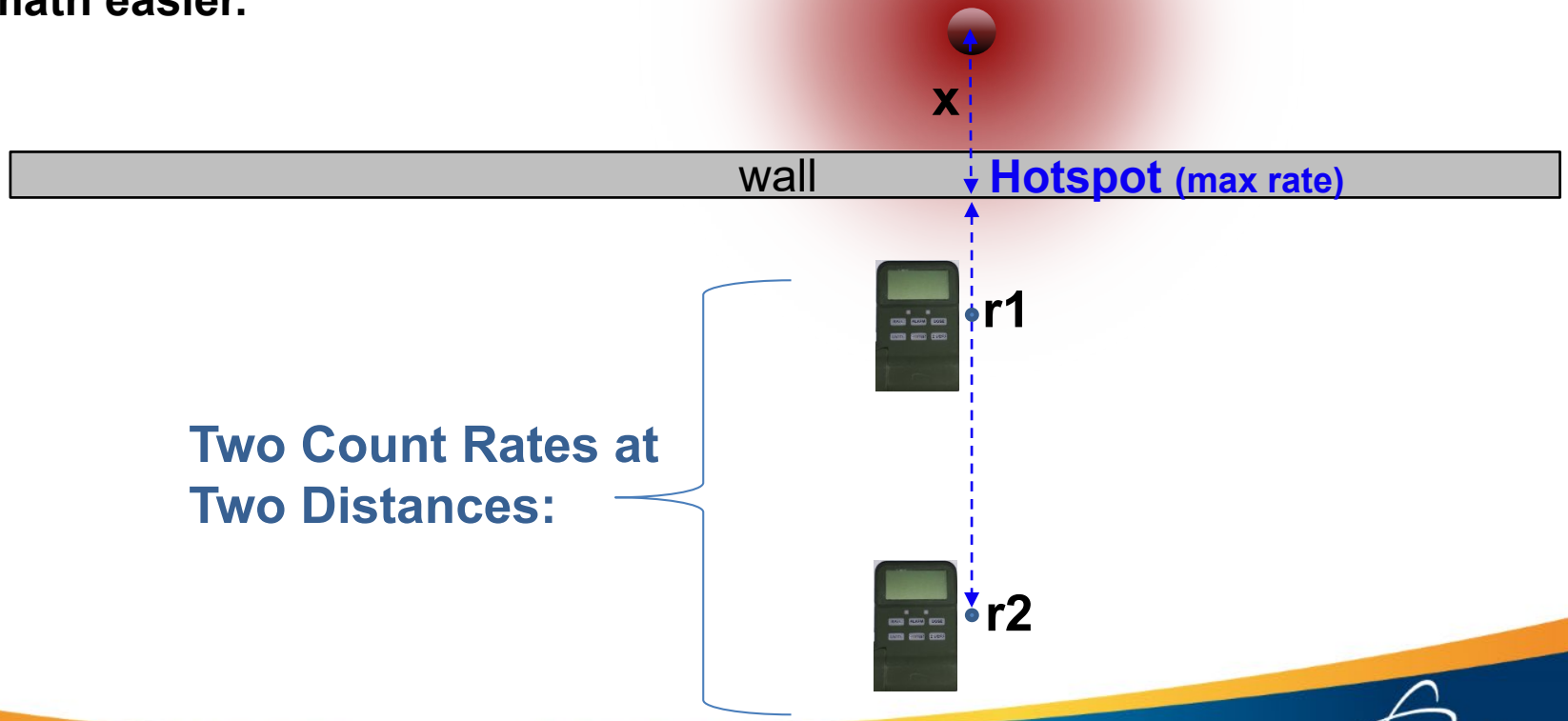


Job Aid:

1) Determine the background (BG) rate.
2) Calculate Net Rate = Hot Spot Rate – BG
3) Calculate ¼ Net = ¼ (Hot Spot – BG).
4) Then move directly away from the wall until the rate on the instrument is (¼ Net + BG)

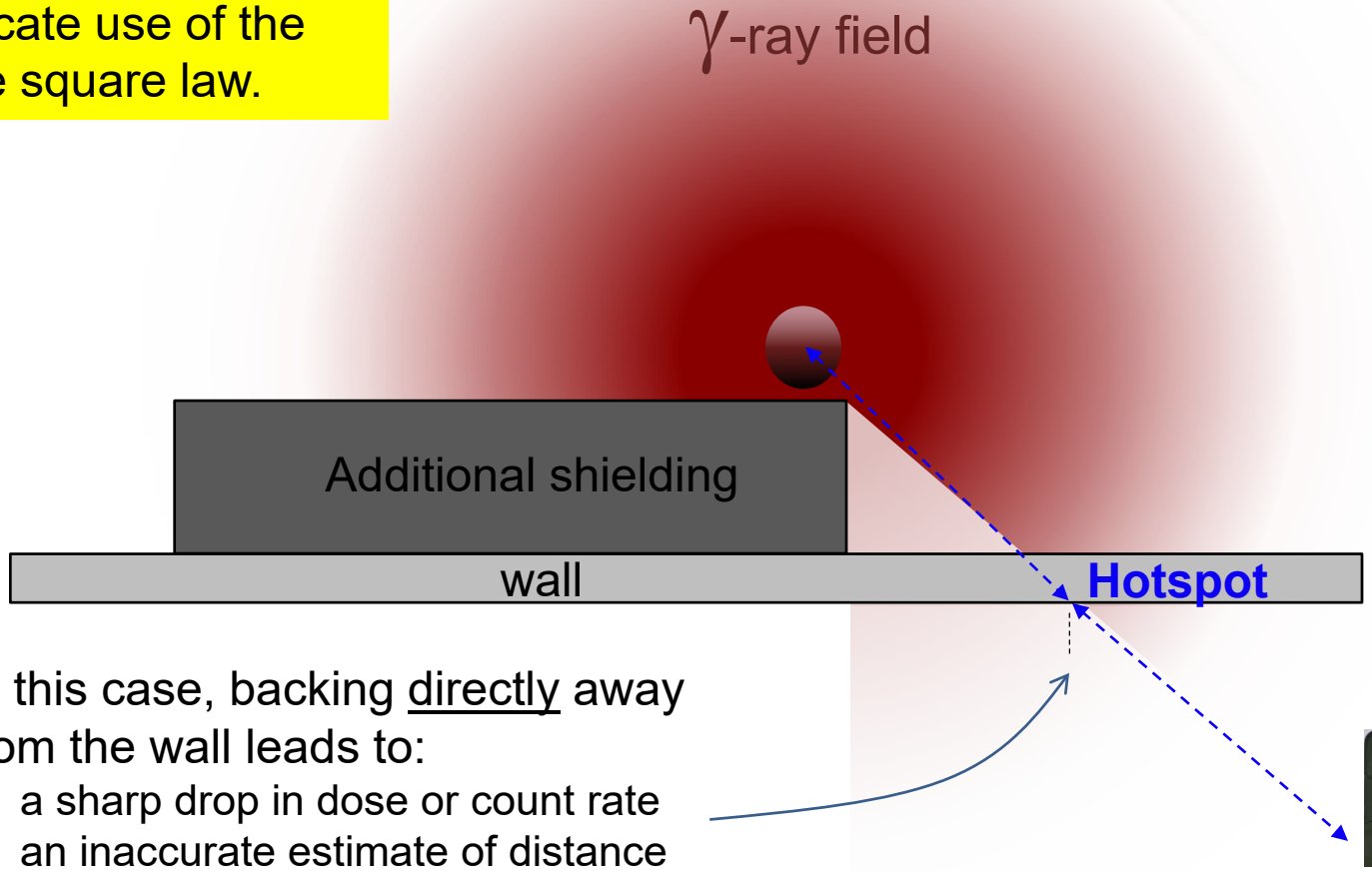
When You Can't Get the Hot Spot Rate

If the hot spot rate is too hot just provide 2 count rates at two different distances. Rate 2 does not have to equal ¼ of Rate 1 but it does make the math easier.



Issues with Complex Shielding

Unknown shielding geometries can complicate use of the inverse square law.



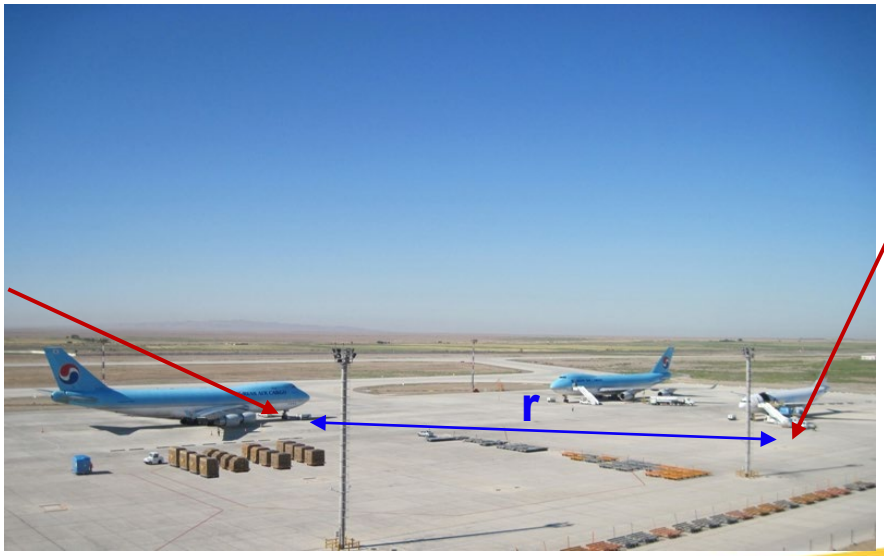
In this case, backing directly away from the wall leads to:

- a sharp drop in dose or count rate
- an inaccurate estimate of distance between source and detector

Searching for Hot Sources

- You may detect them from very far away
- You may search only a few feet at a time
- The distance, r, is barely changing
- The radiation intensity will appear constant

If there is a strong source here …

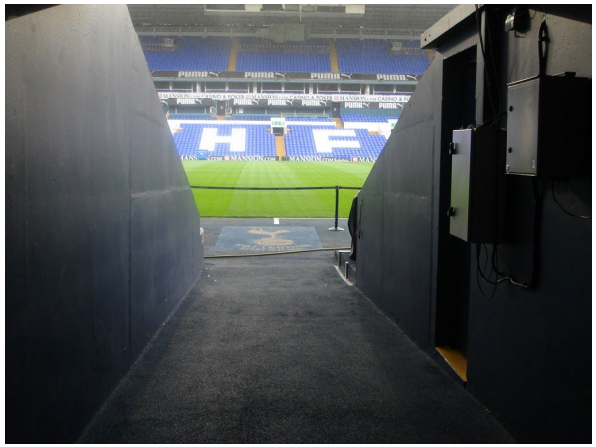


But you are over here….

Then as you move a foot or two you are only changing ‘r’ by a few percent. So the count rate does not change that much.

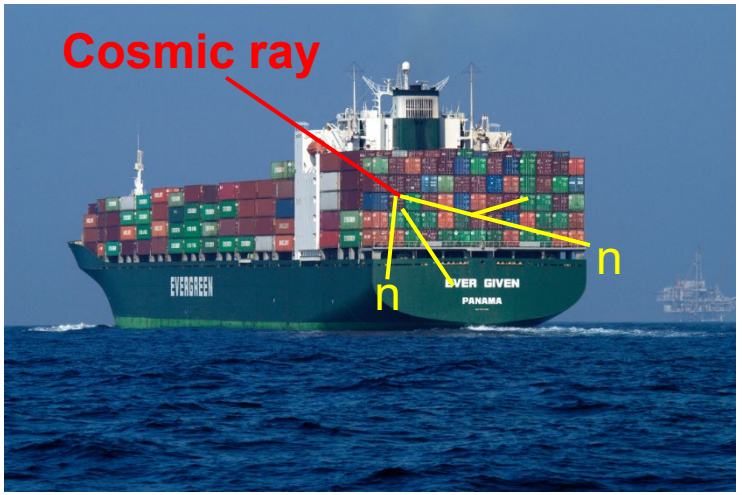
Searching for Hot Sources

- Restrict the field of view of your detector to determine the direction to the source
  - Using your own body
  - Using other objects such as columns, walls, etc



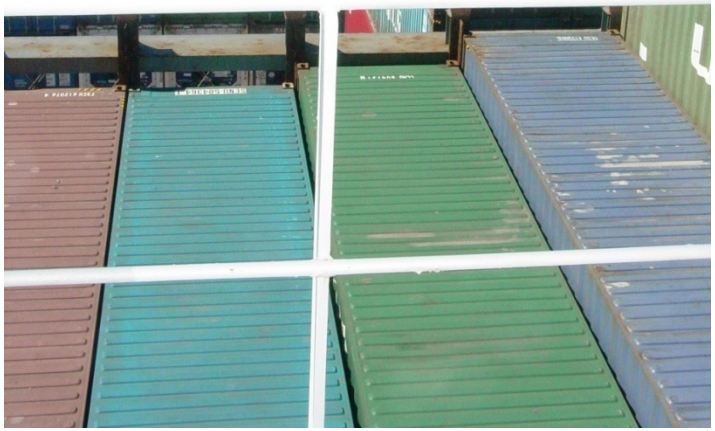
Ship Effect

- Gamma and Neutron rate over water is low compared to over land
- Detectors updated/powered on over open water may alarm when they arrive at a large ship
- Cosmic rays strike the massive metal of the ship and generate neutrons.



Since cosmic ray rates fluctuate, the neutron rates on the ship due to them will fluctuate.

Palermo Senator



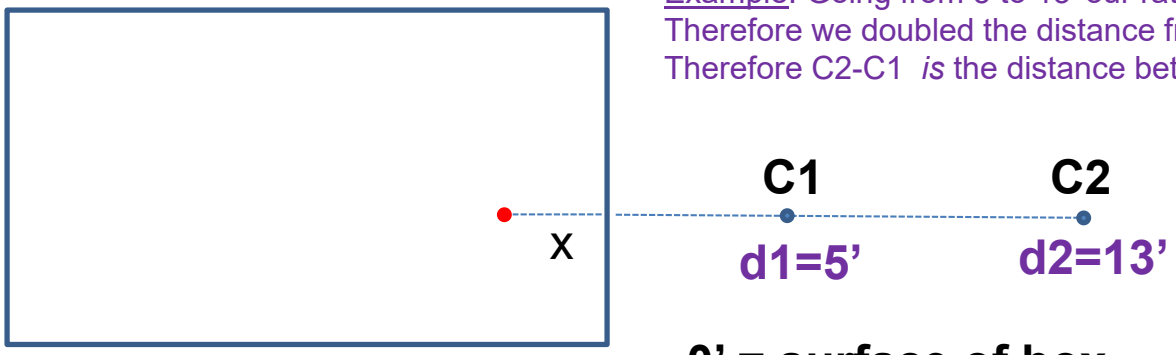
Palermo Senator

- 708 ft. Small/Med.-size container ship, Liberian registry
- Hong Kong → Malaysia → Singapore → Gioia Tauro, IT → Felixstowe, BG → Valencia, ES → Fos Sur Mer, FR → LaSpezia, IT → Balaruc, FR → NYC, USA
- 1308 containers (8x8x20', 8x8x40')
  - 258 contained ceramic and clay tiles
  - 34 contained marble
  - 12 contained granite
  - 9 contained stoneware and pottery
  - 4 contained cocoa butter and coca powder
  - 5 contained minerals and chemicals
  - 3 contained refractory brick

i.e. a significant percentage of innocent radioactive cargo

Activity

- One person draws:
  - A box and two count rates **C1** and **C2** at distances **d1** and **d2** in a line 90° to the box surface
  - Assume the count rate **C2 = ¼ C1**
- The other person completes the drawing with the source location inside the box



Example: Going from 5 to 13’ our rate dropped to ¼ C1
Therefore we doubled the distance from C1 to the source.
Therefore C2-C1 *is* the distance between C1 and the source = 8 feet.

0’ = surface of box

Summary

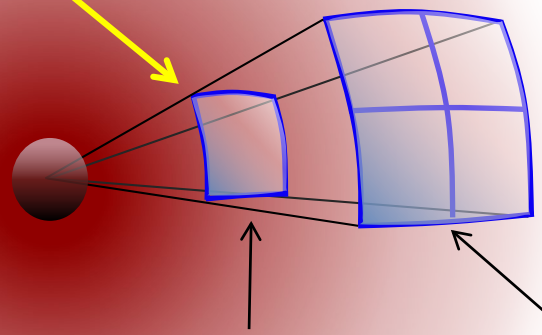
- Detection of gamma rays is affected by:
  - Shielding type and thickness
  - Distance
  - Source intensity
  - Detector
- The ISL will not work well for:
  - Extended sources
  - Complex shielding situations
- The ‘3D-T’ search process involves finding a hotspot in one direction, then, working in 90-degree angles (“tees”), finding the hotspots in the other two directions.

Appendix

- The following concepts have been covered in the HP presentation but are included here for reference.

The Inverse Square Law ($1/r^2$)

Let's say 1 square = the area covered by your detector.



γ-ray field

distance = r
area = A
e.g. 400 cps

distance = 2r
area needed for same rate = 4A
Rate for 1 square = 100 cps

Count rate

$$C \propto \frac{1}{r^2}$$

Source-to-detector distance

If you *double* the distance, the count rate drops by a factor of 4